National Transmission Planning Study: Briefing for MGA States

October 30, 2024

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U.S. Department of ENERGY

AGENDA

1. Introduction and context
2. NTP Study toplines
3. Midwestern results
4. How can the states further use the NTP Study
5. Questions and discussion

THE NTP STUDY WAS PUBLISHED ON OCTOBER 3, 2024

You can find the National Transmission Planning Study on DOE's website:

https://www.energy.gov/gdo/national-transmission-planning-study

The public webinar was on October 16th and the recording is also available on the DOE website:

https://www.energy.gov/gdo/events/october-16-national-transmission-planning-study-informational-webinar

NTP STUDY GOALS

The National Transmission Planning Study combines innovative methods with state-of-the-art industry practices to analyze the role and value of transmission in future power systems.

Specifically, the study sought to:

- Develop new national grid-scale planning tools and methods that can be used by industry, especially when planning for interregional transmission capacity needs;
- Identify potential transmission solutions that will provide broad-scale benefits to electric customers under a wide range of potential futures;
- Inform planning processes for regional and interregional transmission; and
- Identify interregional and national strategies to maintain grid reliability as the grid transitions, including to a reliance on low- and zero-carbon energy resources.

WHAT THE STUDY DOES AND DOES NOT DO

WHAT THE STUDY DOES DO

- Link several long-term and short-term power system models to test multiple transmission buildout scenarios.
- Provide information that can be used in existing planning processes.
- Test transmission options that lie outside current planning processes.
- Assess a range of economic, reliability, and resilience indicators for each transmission scenario considered.
- Provide companion reports describing opportunities and challenges to realizing potential transmission benefits identified by the study.

WHAT THE STUDY DOES NOT DO

- Replace existing regional and utility planning processes.
- Site specific locations or provide approvals for individual transmission lines.
- Address the detailed environmental impacts or other land use issues of potential future transmission lines.
- Develop detailed plans of service or provide results that are as granular as planning done by utilities.
- Provide a roadmap for developing specific projects.

OBJECTIVES OF THIS MEETING

- Share key findings, tools, and methodologies with the MGA States
- Provide a regional look at the results
- Answer questions
- Understand may be most helpful going forward
- Encourage and open the door for continued engagement

ENGAGEMENT DURING THE MEETING TODAY

- Add questions or comments to the chat at any time
- We'll pause for questions throughout the presentation
- We'll leave time at the end of the meeting for Q&A

STUDY METHODS AND SCENARIOS

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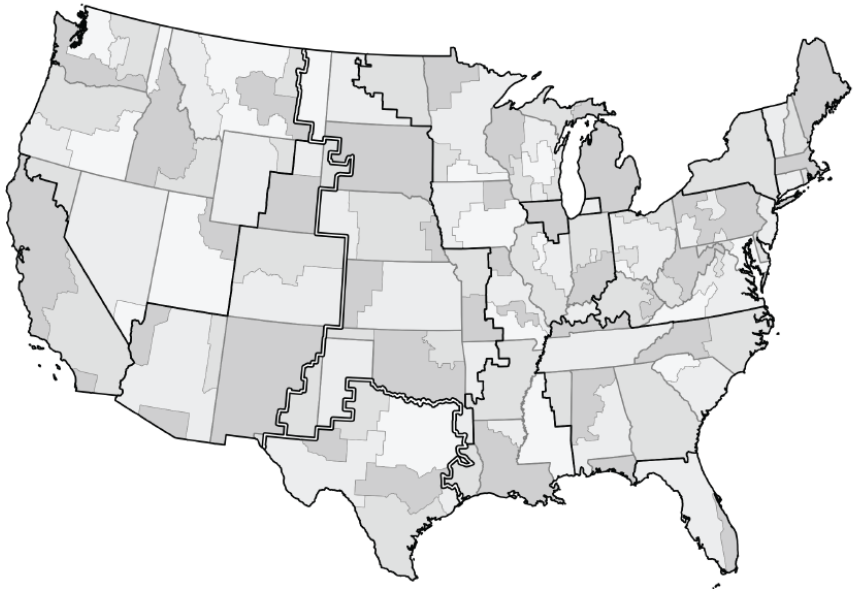
Multimodel analysis for a low-cost, reliable transmission system of the future



Zonal Resolution
Long-Term Scenarios through 2050

- Capacity Expansion
- Economic Analysis
- Resource Adequacy

Nodal Resolution
2035 Transmission Portfolios

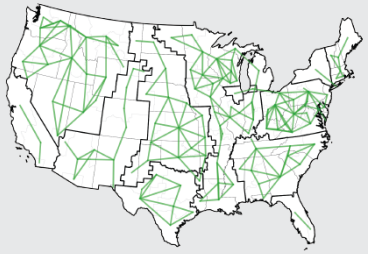
- Production Cost
- Power Flow
- Stress Analysis

SCENARIOS

TRANSMISSION FRAMEWORKS

Reference Transmission Framework

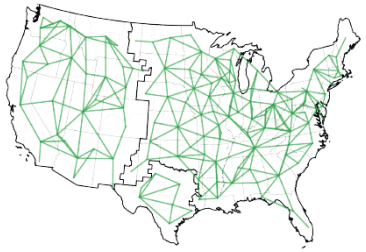
Limited (Lim)



- No new interregional transmission
- Total annual transmission expansion limited to recent observed maximum

Accelerated Transmission Framework

Alternating Current (AC)



- Expansion allowed within interconnections
- No new DC connections

Point-to-Point (P2P)

- Expansion allowed across the country
- Includes long-distance point-to-point HVDC options

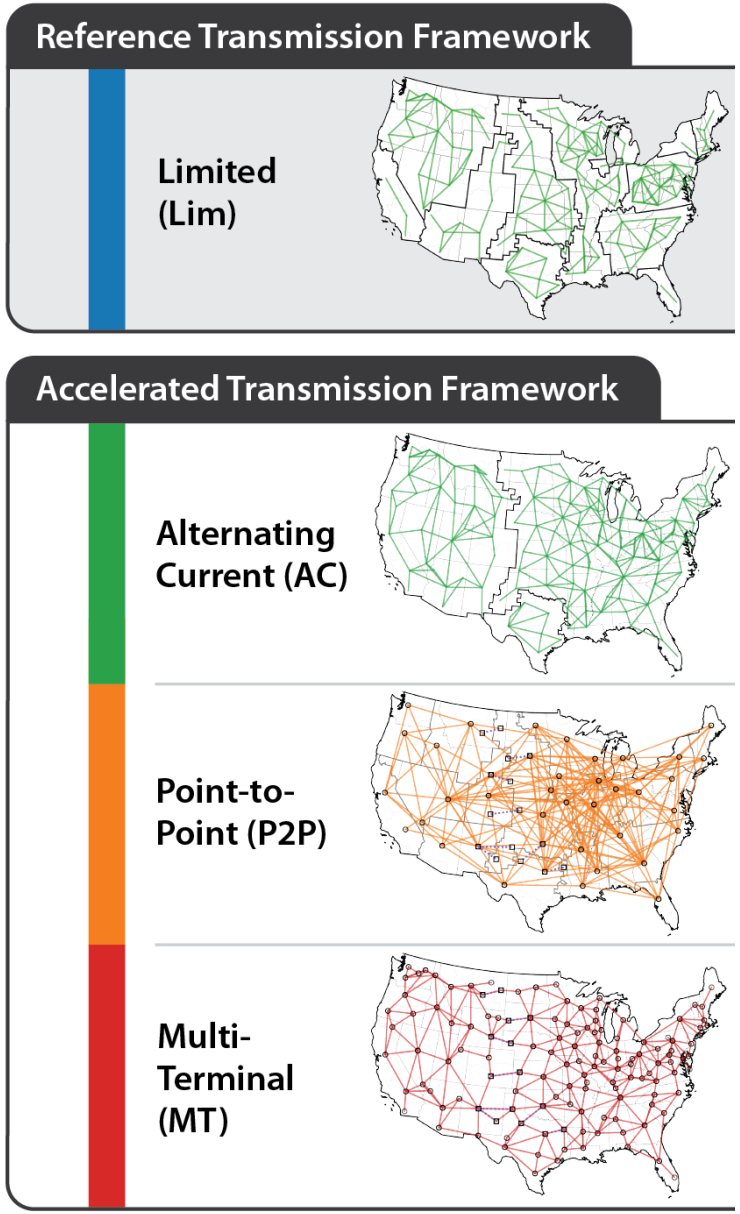
Multi-Terminal (MT)

- Expansion allowed across the country
- Includes multi-terminal HVDC options between neighboring zones

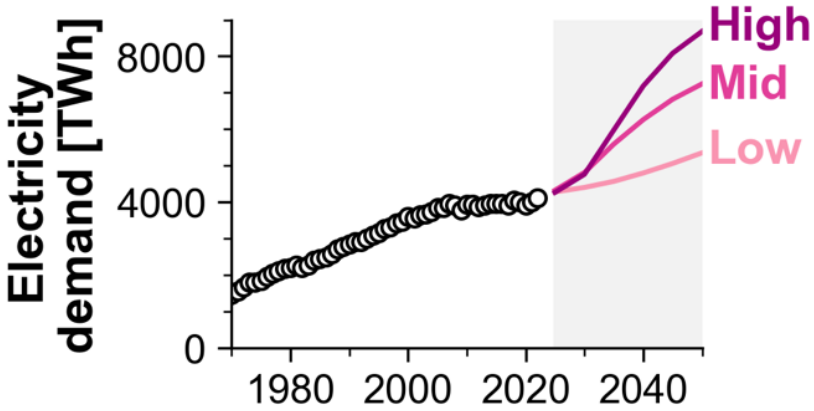
SCENARIOS

TRANSMISSION X DEMAND X EMISSIONS TARGETS

36 CORE SCENARIOS



× 3 Demand Growth



× 3 Emissions Targets
Current policies
90% CO_2 reduction by 2035
100% by 2035

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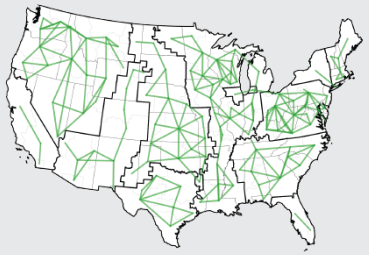
Goal is to understand role of transmission across many possible futures

SCENARIOS

SENSITIVITIES

Reference Transmission Framework

Limited (Lim)



Accelerated Transmission Framework

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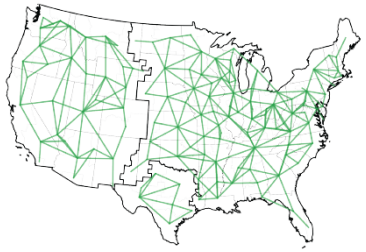

Point-to-Point (P2P)

Multi-Terminal (MT)

× 15 Sensitivities*

Sensitivity
PV + battery low cost
Wind low cost
Electrolyzer low cost
+Nuclear SMR +DAC
No interface expansion limit
Transmission cost 2x
No resource adequacy sharing
Siting limited for PV and wind
CCS high cost
Many challenges
No H2
No CCS
No H2 or CCS
No H2 or new nuclear
Climate

**Full set of sensitivities modeled for the central (90% by 2035, Mid-Demand) case only*

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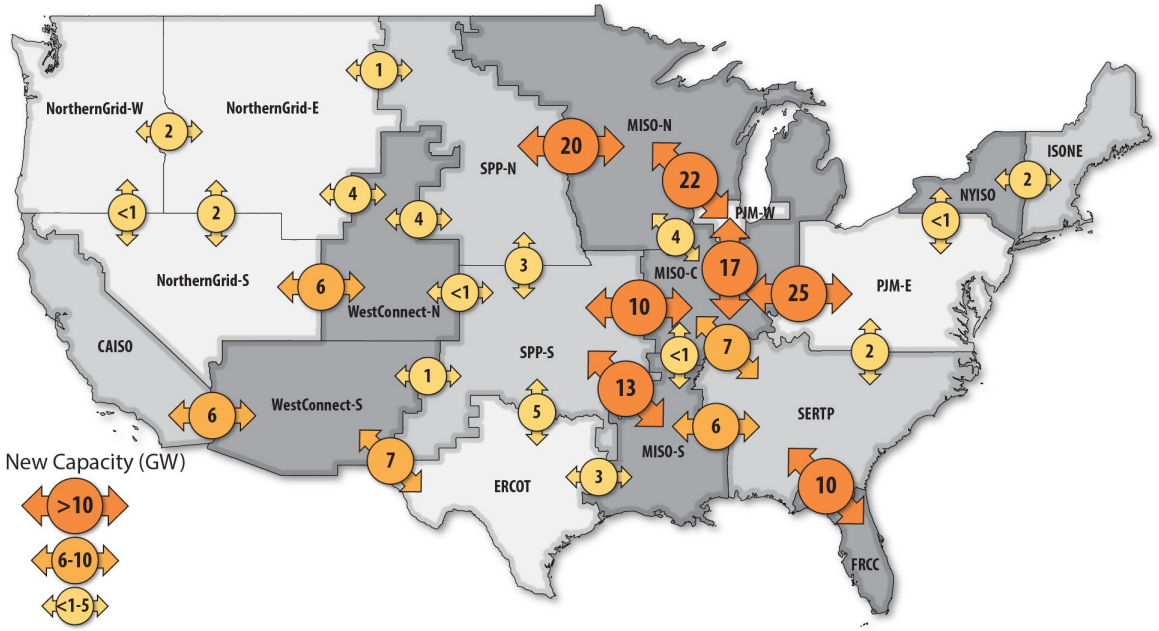
NTP STUDY TOPLINES

NTP STUDY FINDINGS SUMMARY

GRID RELIABILITY: Improving interregional transmission can enhance grid reliability, particularly in response to extreme weather events, as it allows more resources to be shared across regions and energy to be moved from where it is available to where it is needed.

CONSUMER SAVINGS: A substantial expansion of the transmission system throughout the entire contiguous United States delivers the largest benefits to consumers and would save the U.S. **$270-$490 billion** through 2050, with approximately **$1.60 to $1.80** in system cost savings for every dollar spent on transmission.

INTEGRATING NEW, CLEANER GENERATION ONTO THE GRID: Expanded transmission enables the grid connection of new generation projects, balancing the variability of wind and solar resources and accommodating growing energy demands while maintaining system reliability and energy affordability.



High Opportunity Transmission (HOT) interfaces represent potentially beneficial transmission capacity expansion between regions found across many future power system scenarios. Transmission projects that align with these HOT interfaces could be strong candidates for further study and serve as a starting point for accelerated transmission expansion.

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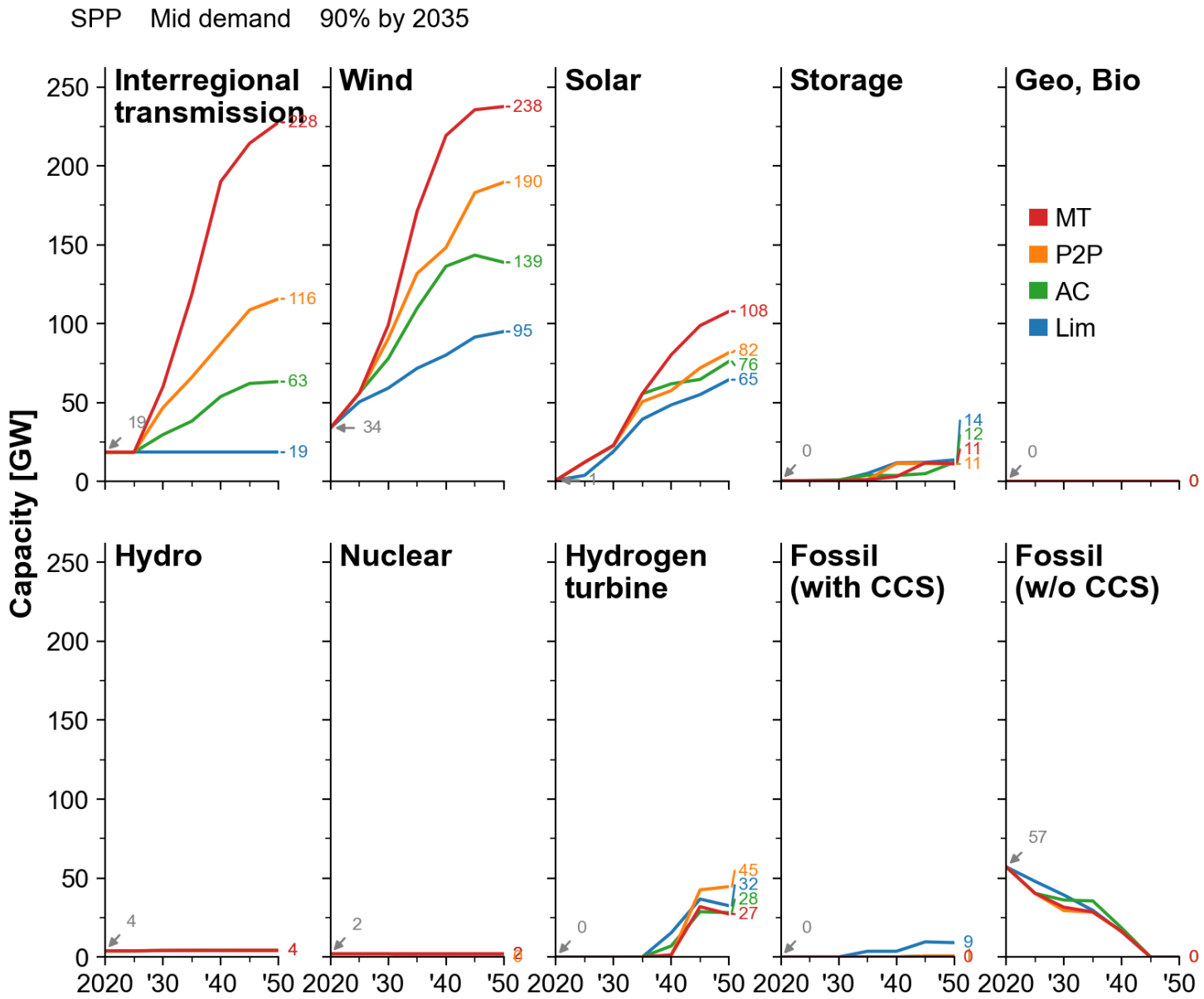
MIDWESTERN RESULTS

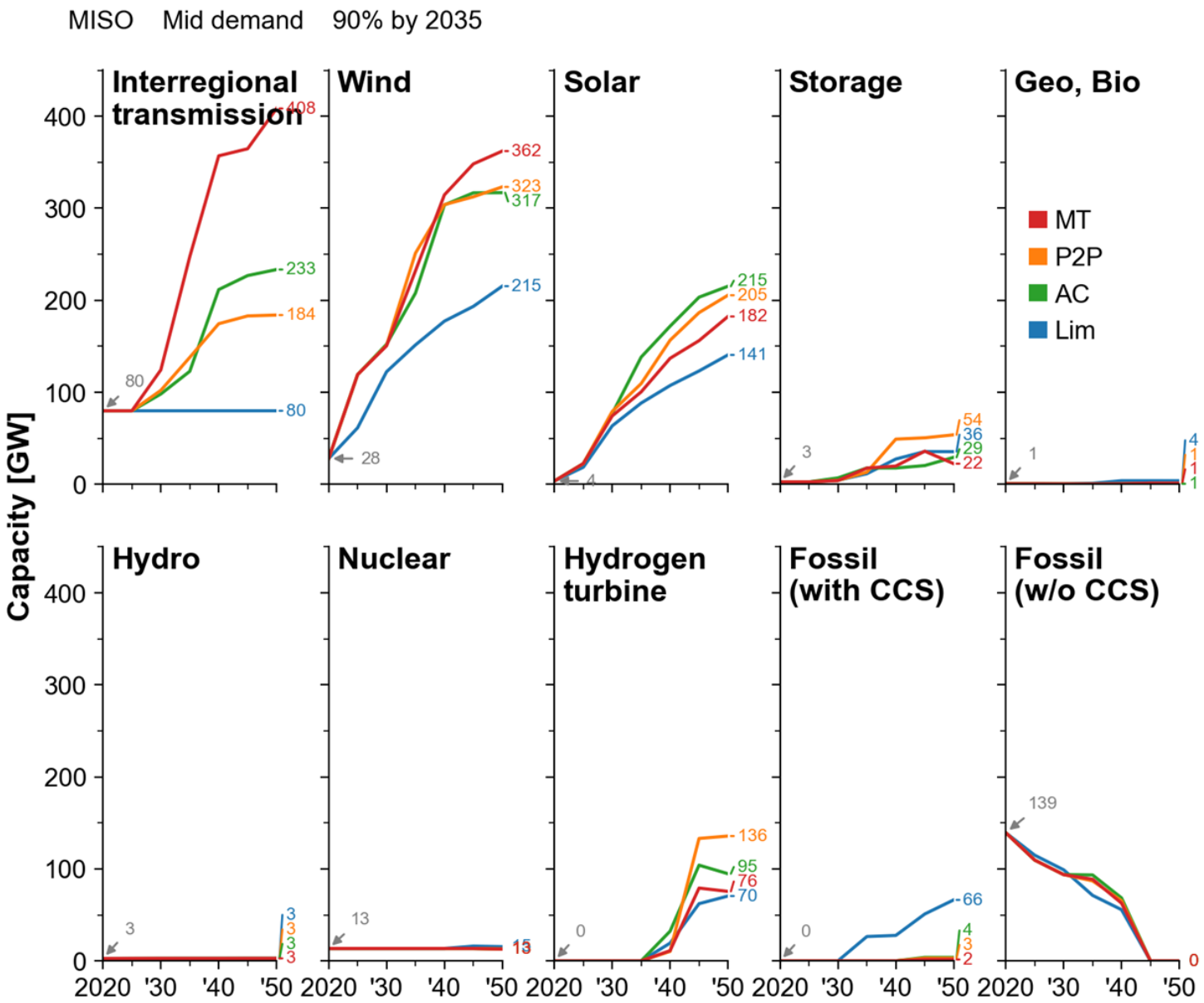
CAPACITY EXPANSION

SPP



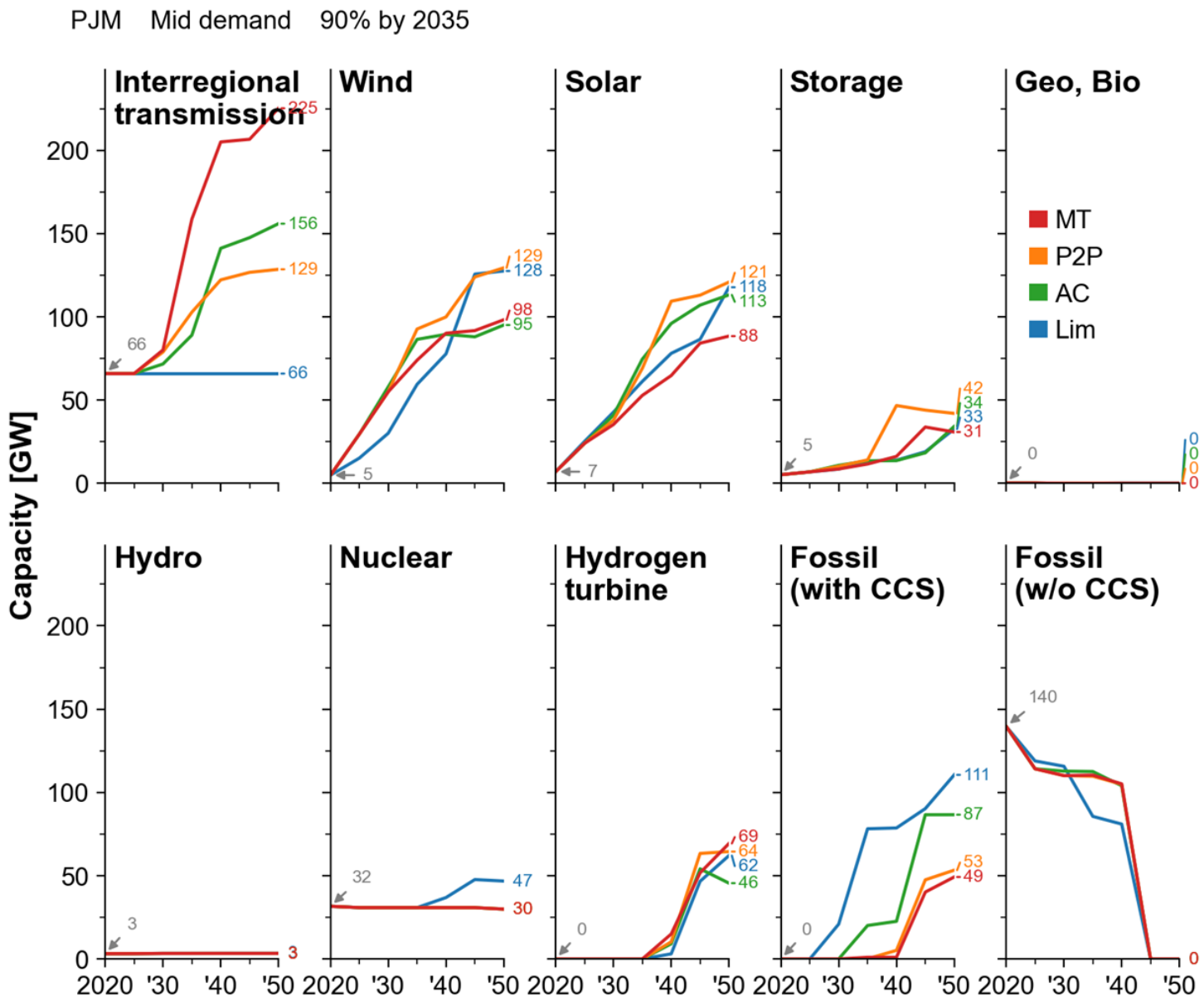
CAPACITY EXPANSION

MISO



CAPACITY EXPANSION

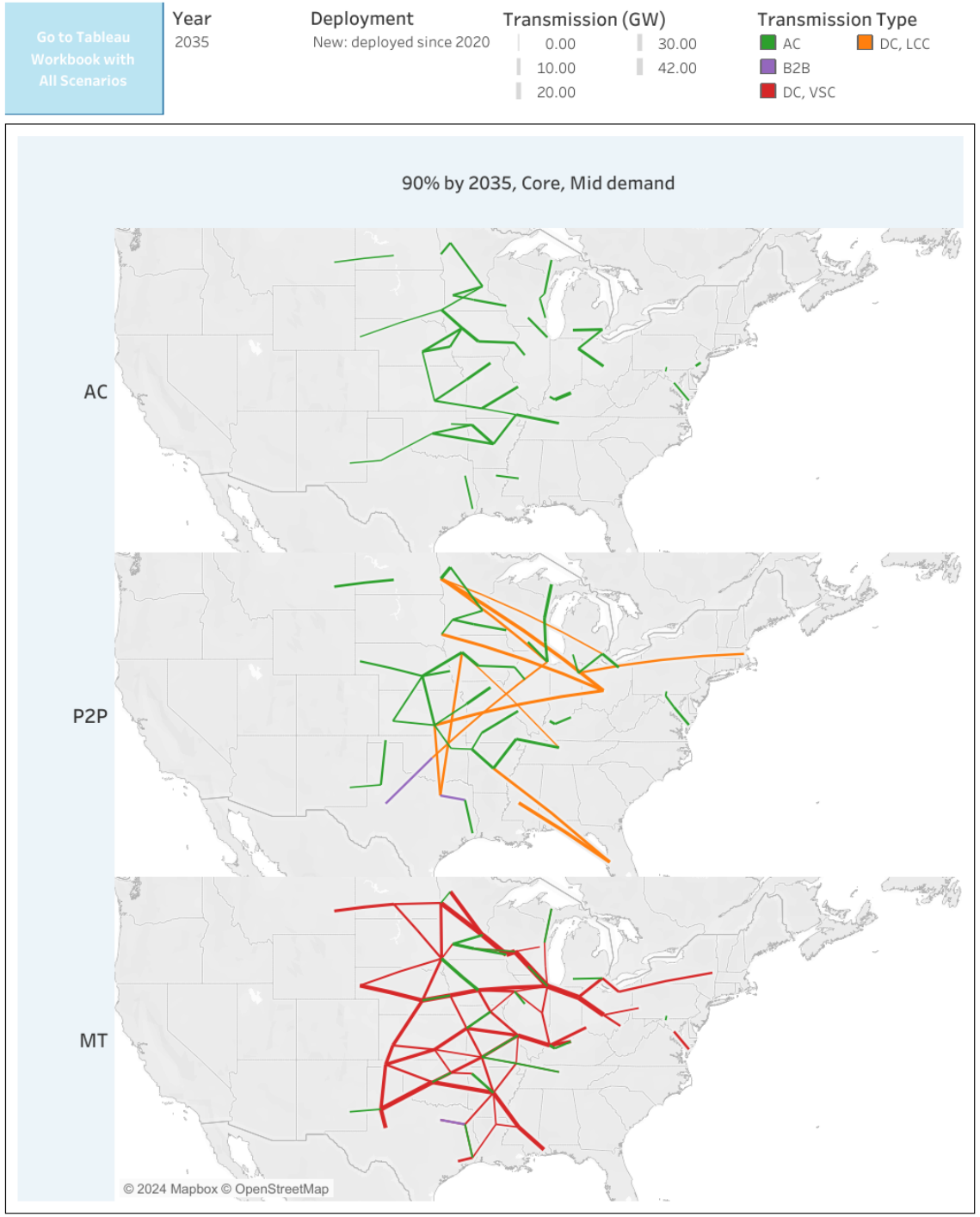
PJM



INTERREGIONAL TRANSMISSION RESULTS

SPP, MISO, & PJM

SCENARIO VIEWER



HOW CAN THE STATES USE THE NTP STUDY?

NEXT STEPS – TURNING THE FINDINGS INTO ACTION

Share the findings and analytical tools developed by the labs with transmission planning entities, RTOs/ISOs, utilities, and states to help **advance planning of interregional transmission**

Encourage examination by planners of **high opportunity transmission options** identified in the NTP Study

Inform DOE's use of financing and permitting tools:

- E.g., Transmission Facilitation Program, NIETC Designation, 2026 Needs Study, etc.
- NTP study results may help GDO shape programs and applicant submissions, but results do not affect selections processes.

NTP STUDY TOOL & METHODS DEVELOPMENT

Nationwide capacity expansion modeling

Zonal to nodal model disaggregation

- Detailed system modeling to analyze system costs and operations

Chronological AC Power Flow Automated Generation (C-PAGE) tool

- Samples many timeframes to analyze sequential snapshots of the most stressed hours of a year

Extreme event and climate change on load

ARE THERE OPPORTUNITIES TO EXPAND ON THESE TOOLS, DATA, AND RESULTS TO ASSIST STATES?

Additional capacity expansion modeling (scenario development) that could inform resource assumptions in existing planning process from a multi-regional basis

Interregional model development

- Multi-regional extreme weather events

Development or verification of "best available data," especially in longer-term horizons

- Wind and solar outputs
- Load with climate impacts, electrification, data center projections, etc.

Providing example benefits calculations

- E.g. assessing seven categories of benefits in Order No. 1920

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QUESTIONS & DISCUSSION

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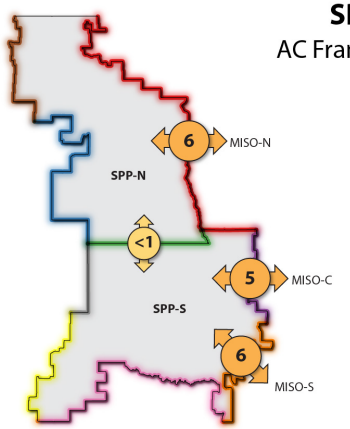
BACKUP SLIDES

SPP

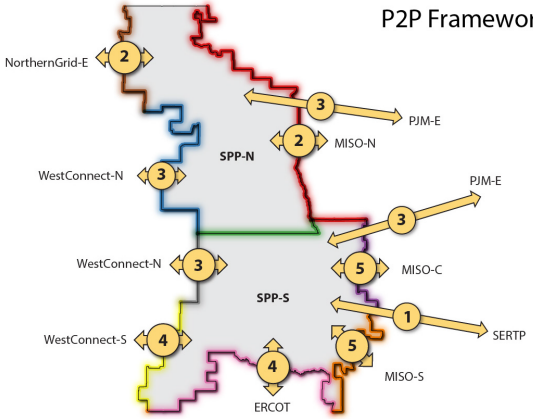
AC Framework



Interface Capacity (GW)

REGION	EXISTING	Percentile of New Capacity 25TH	50TH	75TH
SPP-N, NG-E	0.2	0	0	0
SPP-N, MISO-N	10.0	6.0	7.6	9.4
SPP-N, WC-N	0.5	0	0	0
SPP-N, SPP-S	5.4	0.2	0.3	0.4
SPP-S, MISO-C	2.0	4.7	6.0	6.0
SPP-S, MISO-S	3.3	5.8	6.4	7.0
SPP-S, WC-N	0.2	0	0	0
SPP-S, WC-S	0.4	0	0	0
SPP-S, ERCOT	0.8	0	0	0

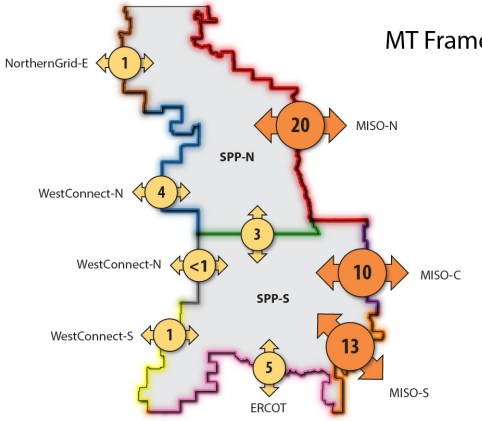
P2P Framework



Interface Capacity (GW)

REGION	EXISTING	Percentile of New Capacity 25TH	50TH	75TH
SPP-N, NG-E	0.2	1.8	2.2	2.5
SPP-N, MISO-N	10.0	1.7	2.6	3.8
SPP-N, WC-N	0.5	2.6	3.1	3.9
SPP-N, SPP-S	5.4	0	0.2	0.7
SPP-S, MISO-C	2.0	4.8	5.6	5.8
SPP-S, MISO-S	3.3	4.5	5.5	6.3
SPP-S, WC-N	0.2	2.7	3.1	3.9
SPP-S, WC-S	0.4	4.2	5.7	6.5
SPP-S, ERCOT	0.8	4.1	5.1	5.7
Nonadjacent Region Interfaces				
SPP-N, PJM-E	0	3.4	5.2	10
SPP-S, PJM-E	0	3.3	4.7	7.1
SPP-S, SRTP	0	1.0	2.5	4.6

MT Framework

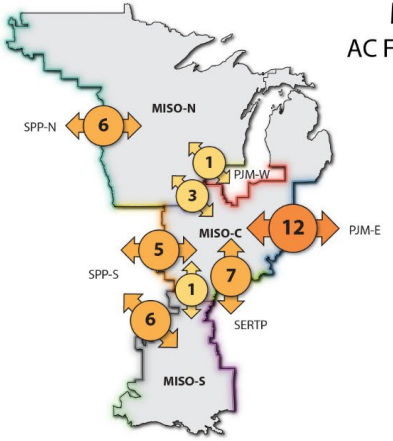


Interface Capacity (GW)

REGION	EXISTING	Percentile of New Capacity 25TH	50TH	75TH
SPP-N, NG-E	0.2	1.2	1.8	2.1
SPP-N, MISO-N	10.0	20.3	24.8	27.8
SPP-N, WC-N	0.5	3.9	5.4	6.6
SPP-N, SPP-S	5.4	3.4	5.8	7.5
SPP-S, MISO-C	2.0	9.9	13.8	16.8
SPP-S, MISO-S	3.3	12.6	16.5	18.1
SPP-S, WC-N	0.2	0.5	0.9	1.5
SPP-S, WC-S	0.4	1.4	1.9	3.7
SPP-S, ERCOT	0.8	4.9	6.3	12.0

MISO

AC Framework



Interface Capacity (GW)

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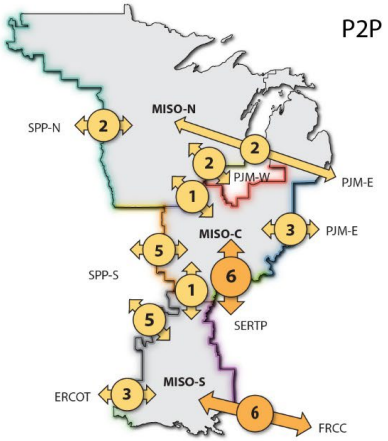
MISO-N, SPP-N	10.0	6.0	7.6	9.4
MISO-N, PJM-W	5.0	1.4	2.9	4.9
MISO-N, MISO-C	5.5	2.6	4.3	5.1
MISO-C, PJM-W	15.1	0	0.7	1.0
MISO-N, SPP-S	1.1	0	0	0
MISO-C, PJM-E	28.3	11.7	14.4	16.1
MISO-C, SPP-S	2.0	4.7	6.0	6.0
MISO-C, SERTP	4.1	7.5	10.1	12.2
MISO-C, MISO-S	2.1	1.4	1.8	2.3
MISO-S, SPP-S	3.3	5.8	6.4	7.0
MISO-S, SERTP	11.0	0	0	0.1
MISO-S, ERCOT	0	0	0	0

P2P Framework



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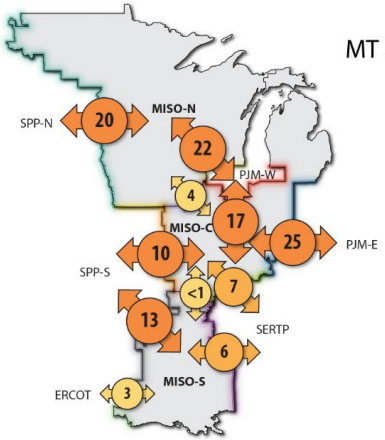
MISO-N, MISO-C	5.5	1.0	1.8	4.3
MISO-C, PJM-W	15.1	0	0	0
MISO-N, SPP-S	1.1	0	0	0
MISO-C, PJM-E	28.3	2.6	4.7	7.9
MISO-C, SPP-S	2.0	4.8	5.6	5.8
MISO-C, SERTP	4.1	5.6	6.8	7.7
MISO-C, MISO-S	2.1	1.2	1.8	2.7
MISO-S, SPP-S	3.3	4.5	5.5	6.3
MISO-S, SERTP	11.0	0	0	0
MISO-S, ERCOT	0	3.3	4.4	4.9
Nonadjacent Region Interfaces				
MISO-N, PJM-E	0	2.0	4.4	7.1
MISO-S, FRCC	0	6.2	7.3	8.6

MT Framework



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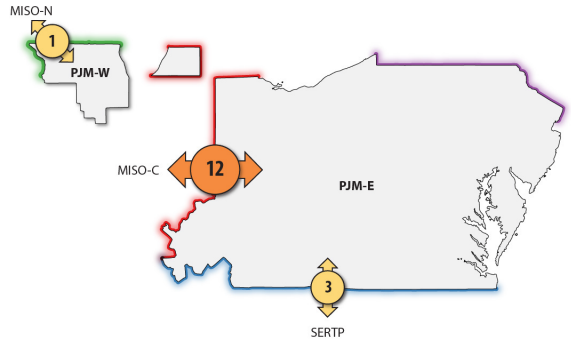
MISO-N, MISO-C	5.5	3.8	5.0	5.5
MISO-C, PJM-W	15.1	16.5	19.7	22.8
MISO-N, SPP-S	1.1	0	0	0.1
MISO-C, PJM-E	28.3	24.7	28.0	32.6
MISO-C, SPP-S	2.0	9.9	13.8	16.8
MISO-C, SERTP	4.1	7.2	9.3	12.5
MISO-C, MISO-S	2.1	0.7	1.3	2.3
MISO-S, SPP-S	3.3	12.6	16.5	18.1
MISO-S, SERTP	11.0	5.8	9.7	11.1
MISO-S, ERCOT	0	2.6	3.7	4.6

PJM

AC Framework



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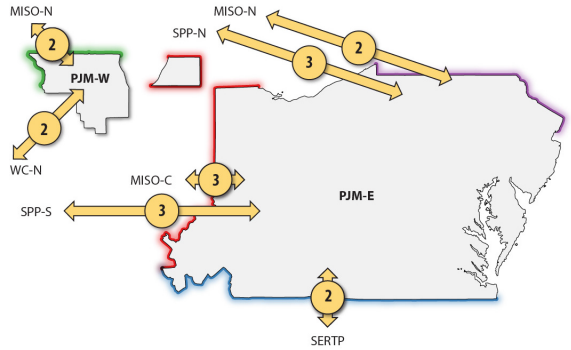
PJM-E, MISO-C	28.3	**11.7**	14.4	16.1
PJM-E, SERTP	10.9	**3.2**	6.8	7.4
PJM-E, NYISO	6.6	**0**	0	0

P2P Framework



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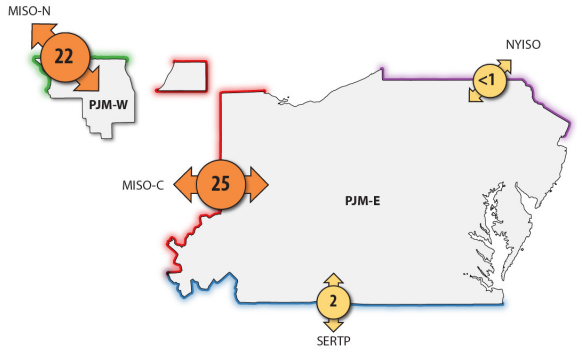
PJM-E, MISO-C	28.3	**2.6**	4.7	7.9
PJM-E, SERTP	10.9	**2.2**	5.0	6.3
PJM-E, NYISO	6.6	**0**	0	0
Nonadjacent Region Interfaces				
PJM-E, MISO-N	0	**2.0**	4.4	7.1
PJM-E, SPP-N	0	**3.4**	5.2	10.0
PJM-E, SPP-S	0	**3.3**	4.7	7.1
PJM-W, WC-N	0	**2.2**	3.1	4.9

MT Framework



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PJM-E, MISO-C	28.3	**24.7**	28.0	32.6
PJM-E, SERTP	10.9	**1.6**	3.8	5.7
PJM-E, NYISO	6.6	**0.9**	2.4	3.7

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NATIONWIDE CAPACITY EXPANSION MODELING: REEDS

Objective: Minimize total **capital + operational** cost of electric power system **subject to…**

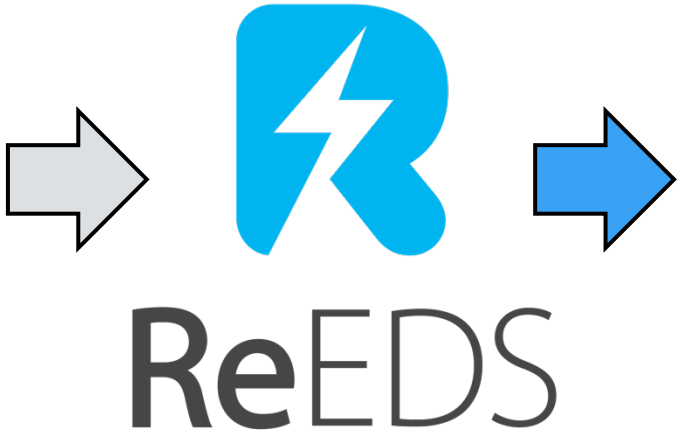
Price-forming constraints: Energy balance; planning/operating reserves; RPS/carbon policies

Additional constraints: Resource availability (spatial & temporal); energy/reserve trading; generation/storage operations; fuel supply; planned builds and retirements; etc.

Inputs

- **Existing & planned** capacity
- **VRE** temporal (hourly) & spatial (11.5km×11.5km) availability
- State & federal **policies** (current and hypothetical)
- **Demand** (hourly) projections for 134 zones across contiguous U.S.
- Capital, O&M, and fuel **cost** projections
- **Technology** availability & performance projections

Regional **E**nergy **D**eployment **S**ystem

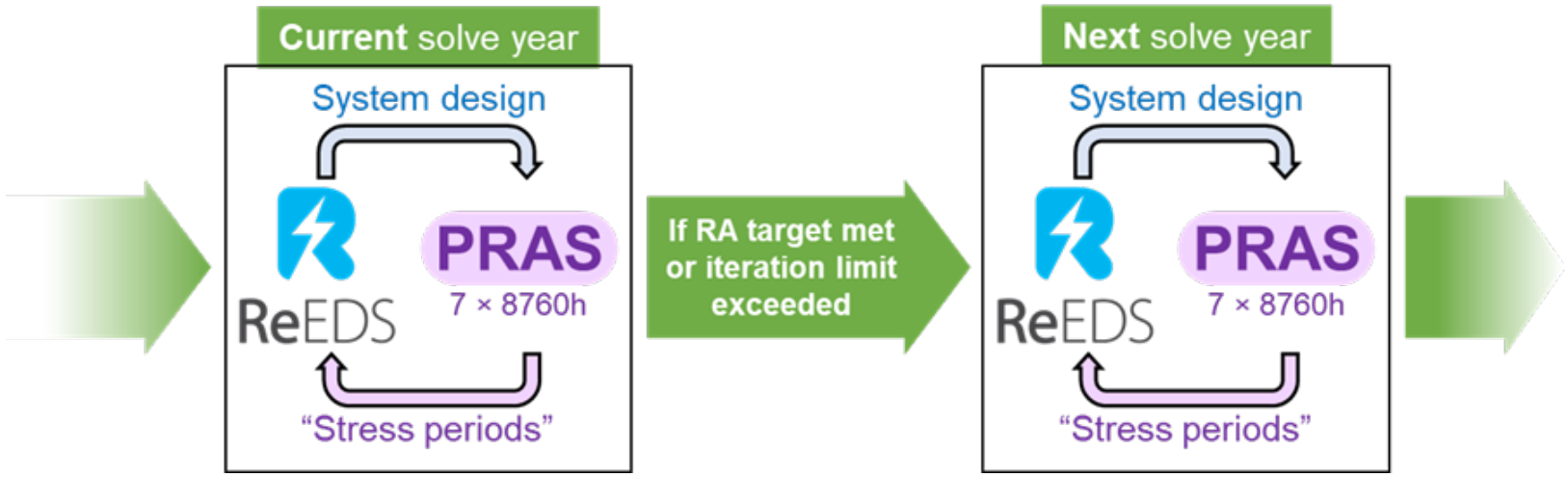


https://www.nrel.gov/analysis/reeds/

Outputs

- Generation and storage **capacity** additions & retirements in each solve year
- **Transmission** capacity additions
- **Operations**: Energy generation, storage levels, firm capacity, & operating reserves by tech
- CO_2, NO_x, SO_2, CH_4 **emissions**
- System **cost** [$billion], electricity **price** [$/MWh]

PROBABILISTIC RESOURCE ADEQUACY SUITE (PRAS)

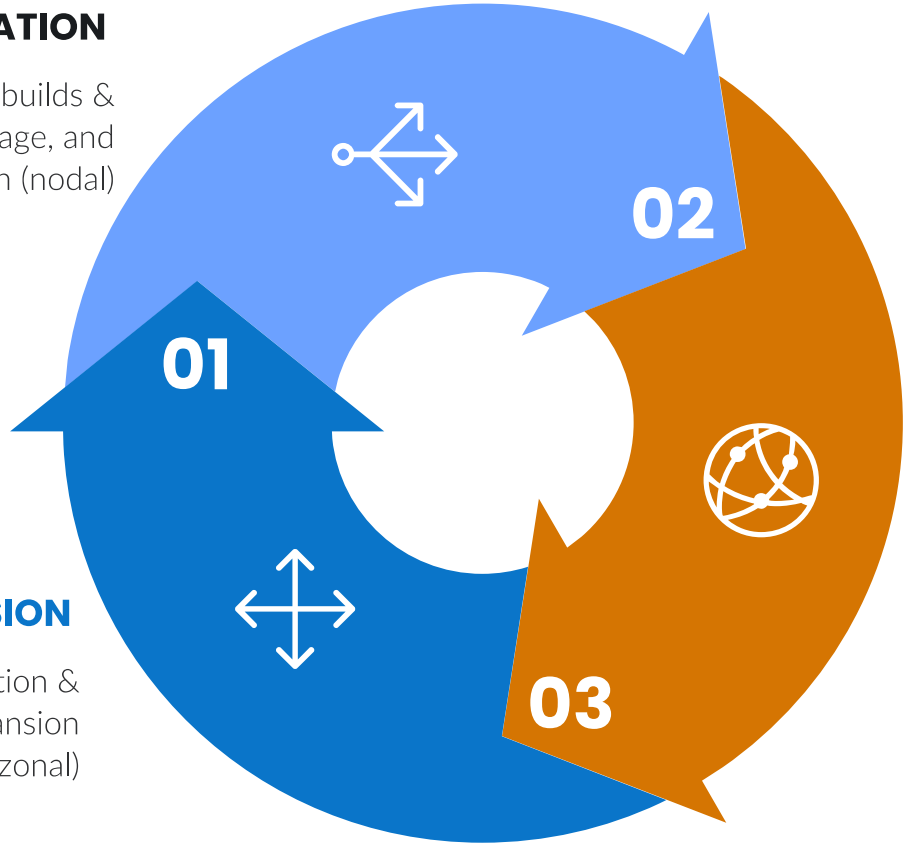


PRAS: Probabilistic Resource Adequacy Suite | Energy Analysis |

ZONAL TO NODAL MODEL DISAGGREGATION

DISAGGREGATION

Generation (new builds & deactivations), storage, and demand disaggregation (nodal)



TRANSMISSION EXPANSION

Iterative transmission expansion planning informed by CEM zonal transmission buildout (utilizing nodal PCM and DC power flow)

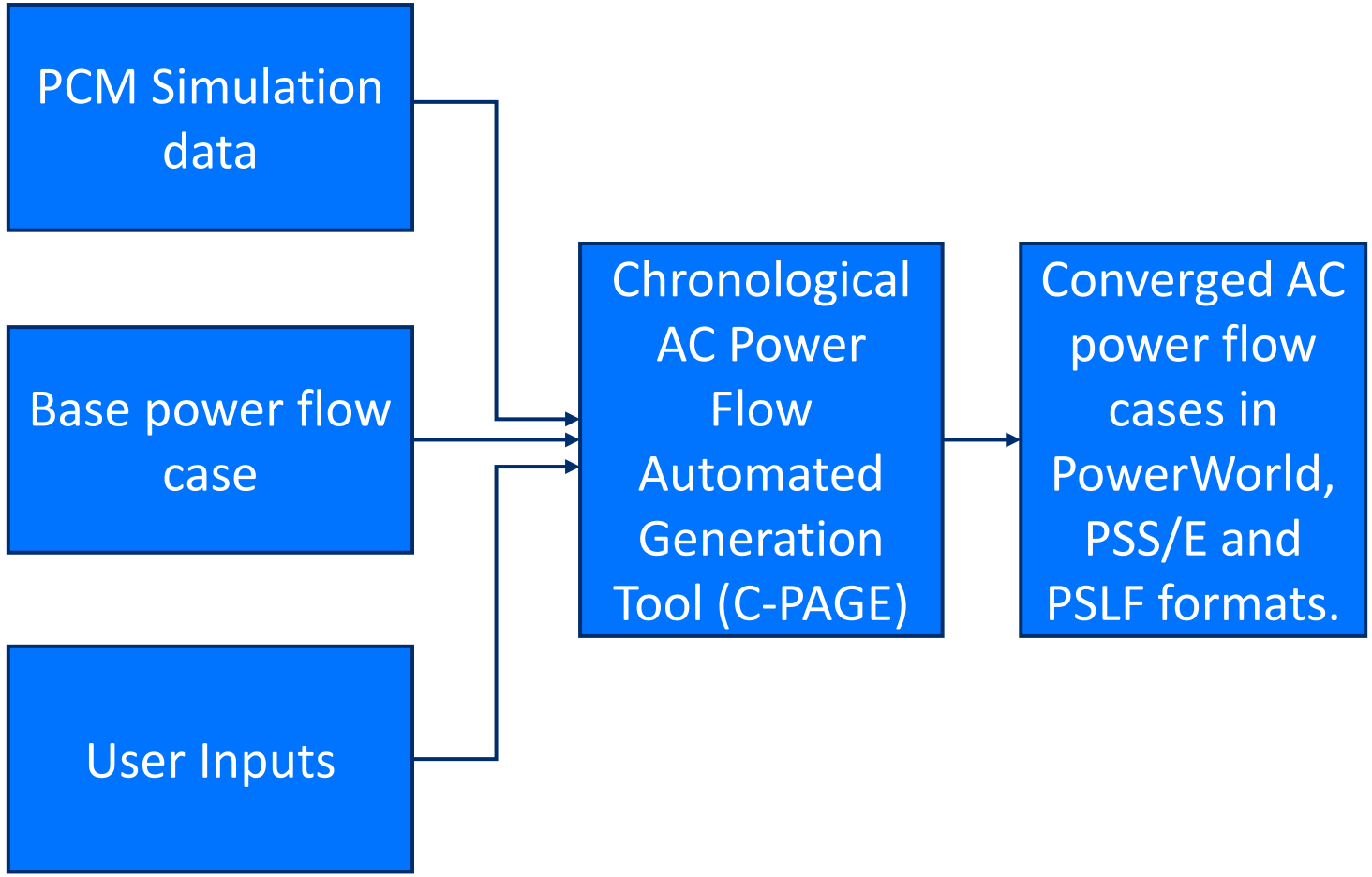
CAPACITY EXPANSION

Optimal generation & transmission capacity expansion planning (zonal)

Overview of zonal-to-nodal translation approach

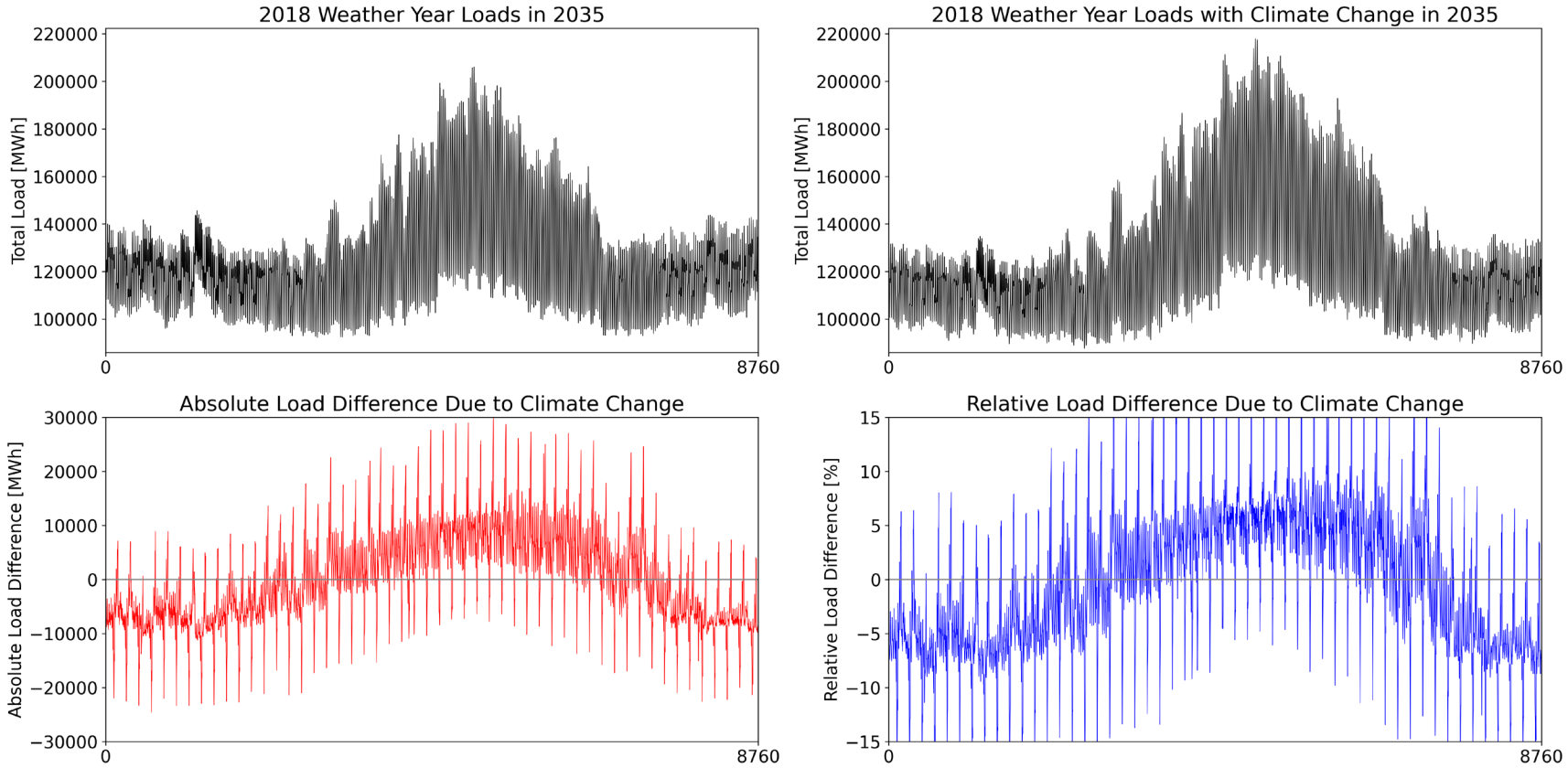
Note: Figure incorporates iteration back to capacity expansion (ReEDS).
CEM = Capacity Expansion Model (ReEDS); PCM = Production Cost Model

CHRONOLOGICAL AC POWER FLOW AUTOMATED GENERATION TOOL



Open-source IEEE Paper: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9416491

EXTREME WEATHER AND CLIMATE CHANGE ON LOAD



PNNL technique allows us to decompose the impact of climate change on load. The addition of the climate change signal to the historical weather decreases winter loads by ~5-7% and increases summer loads by the same magnitude.

U.S. Department of ENERGY

How can we help you realize the benefits in the NTP Study?

AVAILABLE DOE TRANSMISSION PLANNING ASSISTANCE

Program	Lead DOE Office	Principal Researcher	Eligible Applicants	Assistance Mechanism
Grid Resilience Technical Assistance Consortium	GDO	Universities and others	SEOs, PUCs, and Utilities	Initial Partnership Intermediary Agreement – Not currently open
Tribal Nation Transmission Program	GDO	NREL	Tribal Nations	Direct Lab Funding – Ongoing
Wholesale Electricity Market Studies and Engagement Program	GDO	Applicant Selects	States, Tribes, and RTO/ISOs	Rolling Application Rounds – Not currently open
State Technical Assistance Program	EERE/OE	NREL, LBNL, PNNL	PUCs and SEOs	Direct Lab Funding – Ongoing, with future cohorts for deep dive efforts
Clean Energy to Communities Program	Various	NREL	Local governments, Tribes, electric utilities, and community-based organizations	Direct Lab Funding – Ongoing
Technical Support Service	Various	NREL	State, Local, and Tribal	Direct Lab Funding – Ongoing
DOE State Energy Program (SEP) Direct Technical Assistance	SCEP	National Labs	State Energy Offices	Direct Lab Funding - Ongoing and Quarterly Submission Rounds
Utility and Grid Operator TA	EERE	NREL, LBNL, PNNL	Utilities and Grid Operators	Direct Lab Funding - Ongoing and Periodic Submission Rounds